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Supplementary information for

Self-recovering robust electrode for highly efficient CO_2 electrolysis in symmetrical solid oxide electrolysis cell

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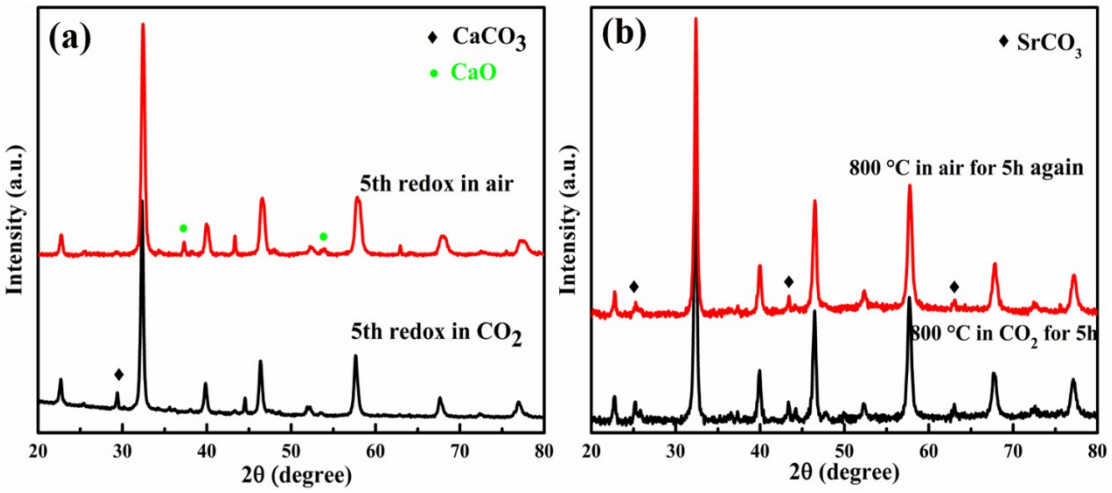

Figure. S1 X-ray diffraction patterns of LCaFN after five redox cycles at 800 °C in air and CO_2 for 5 h (a), LSrFN treated in CO_2 for 5 h and then treated in air for 5 h again (b).

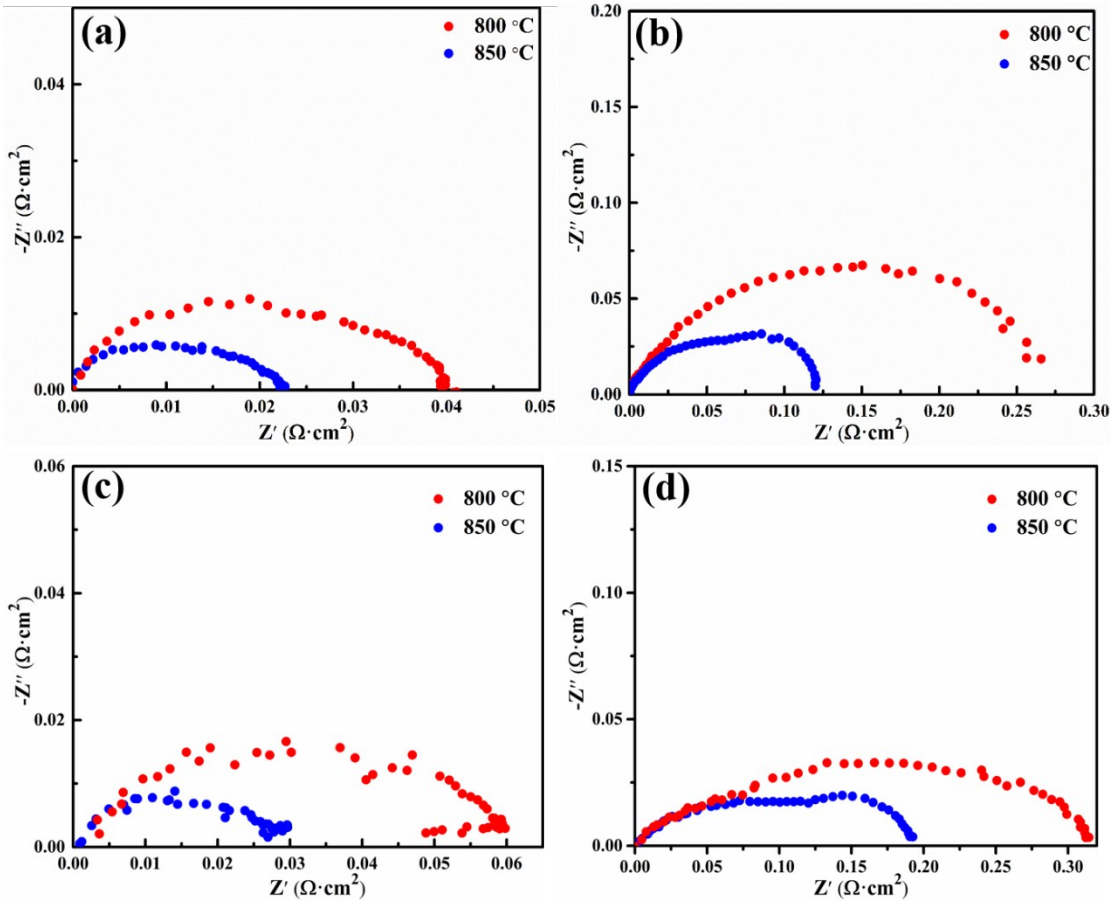

Figure. S2 EIS of LCaFN symmetrical cell tested in half cell mode at different temperature in air (a) and CO_2 (b), LSrFN symmetrical cell at different temperature in air (c) and CO_2 (d).

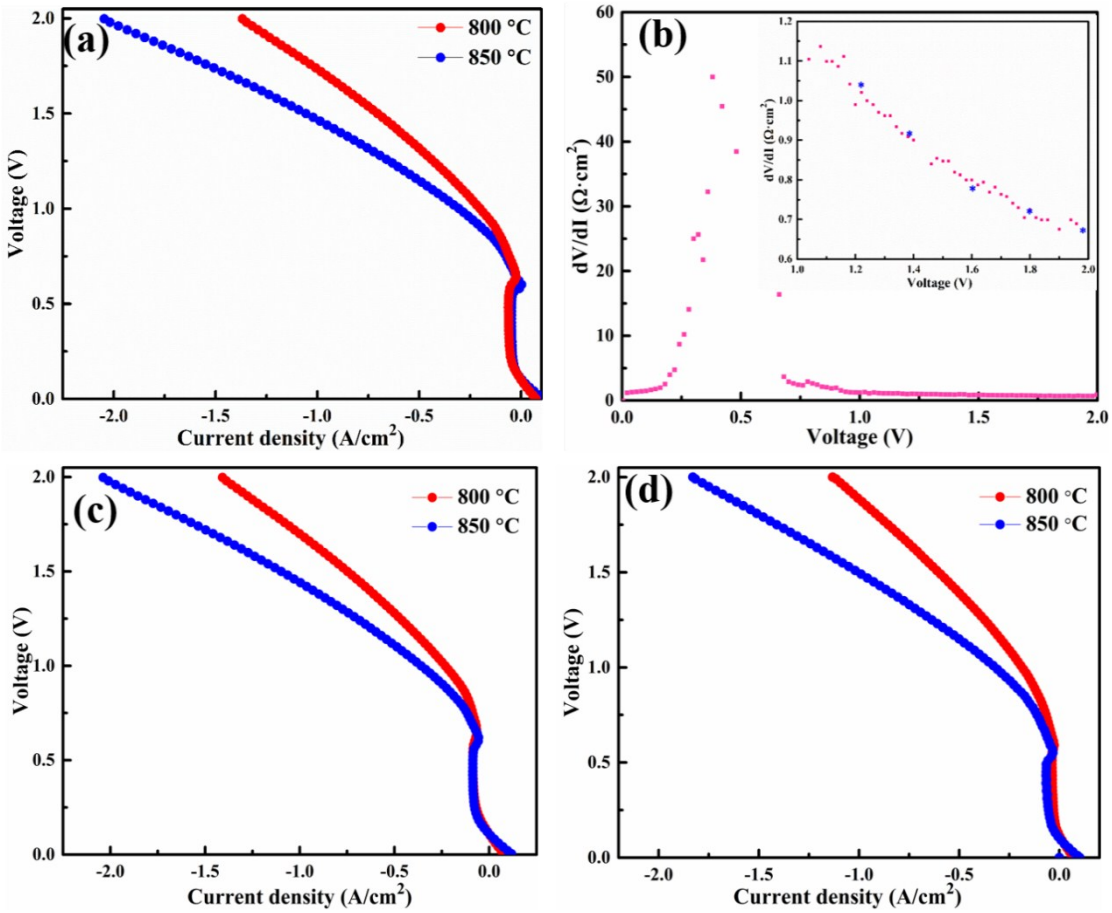

Figure. S3 I-V curves of the LCaFN symmetrical cell for pure CO_2 electrolysis at 800 °C and 850 °C (a) and the corresponding dV/dI–V curve at 800 °C (b). I-V curves of the LCaFN asymmetrical cell (c) and LSrFN symmetrical cell (d) for pure CO_2 electrolysis at 800 °C and 850 °C.

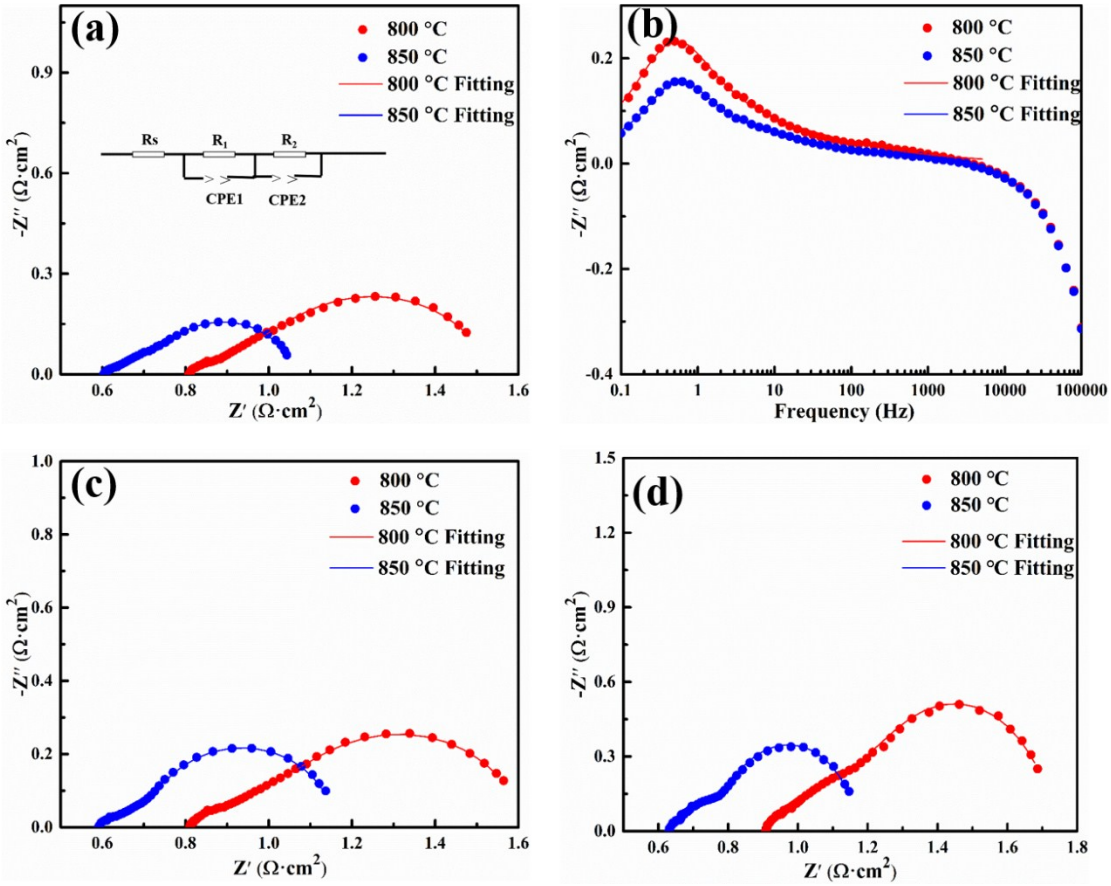

Figure. S4 Nyquist plot (a) and Bode plot (b) of the LCaFN symmetrical cell, Nyquist plots of LCaFN asymmetrical cell (c) and LSrFN symmetrical cell (d) for pure CO_2 electrolysis at 800 °C and 850 °C with fitting by equivalent circuit.

Table S1. Simulated results of the LCaFN, LSrFN symmetrical cell and LCaFN asymmetrical cell in CO_2 at 800 ºC and 850 ºC.

Cell and Testing Temperature (°C)	**R_s(Ω·cm^2)**	**R_1(Ω·cm^2)**	**R_2(Ω·cm^2)**	**R_p(Ω·cm^2)**
LCaFN-asymmetrical-800	0.81	0.37	0.39	0.76
LCaFN-asymmetrical-850	0.60	0.27	0.21	0.49
LSrFN-symmetrical-800	1.05	0.30	0.61	0.91
LSrFN-symmetrical-850	0.72	0.23	0.36	0.59
LCaFN-symmetrical-800	0.76	0.38	0.32	0.70
LCaFN-symmetrical-850	0.57	0.23	0.23	0.46

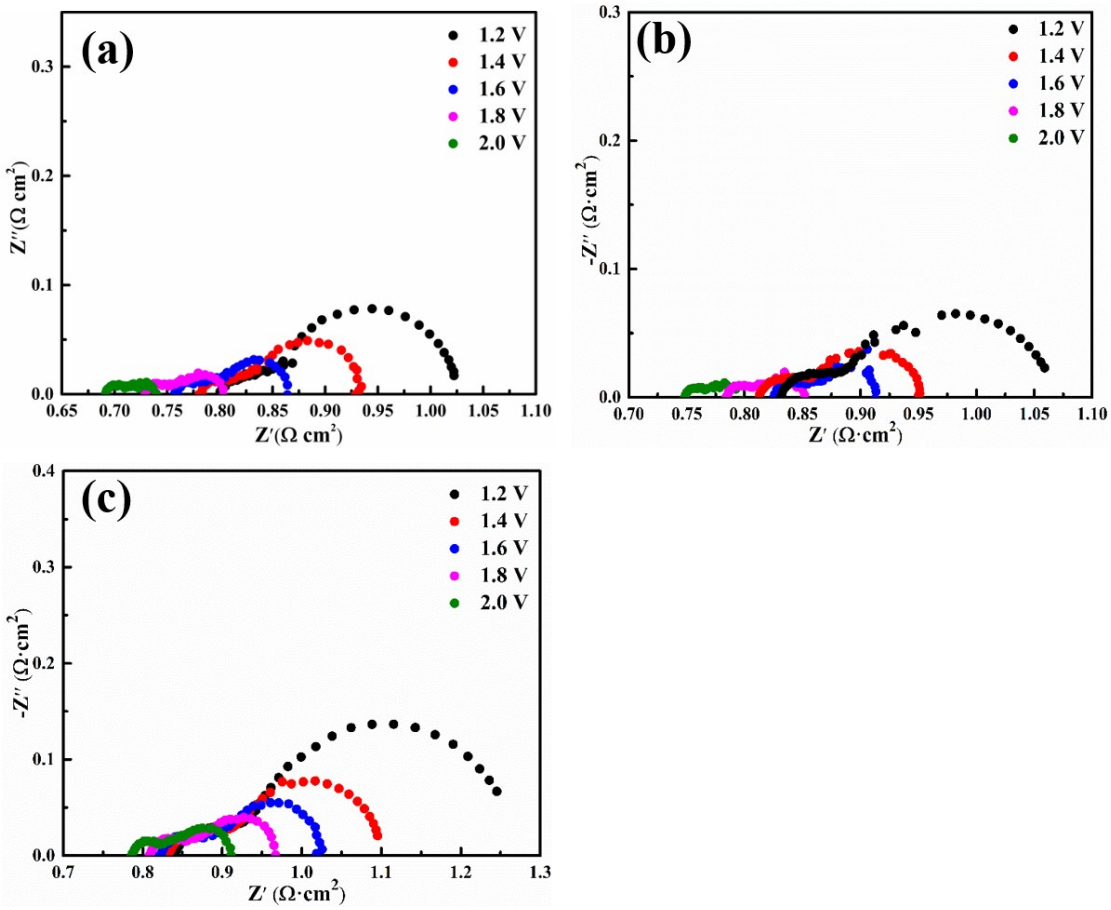

Figure. S5 Nyquist plots of LCaFN symmetrical cell (a), LCaFN asymmetrical cell (b) and LSrFN symmetrical cell (c) under different voltage (1.2~2.0 V) for pure CO_2 electrolysis at 800 °C.

Table.S2 Comparison of the performance of LCaFN symmetrical cell reported in the literature and in the present work.

cathode	electrolyte	anode	Test conditions	Current density (A/cm^2)	R_p ($\Omega \cdot cm^2$)	Ref
$La_{0.75}Sr_{0.25}Cr_{0.5}Mn_{0.5}O_{3-\delta}$	2mm@YSZ	$La_{0.75}Sr_{0.25}Cr_{0.5}Mn_{0.5}O_{3-\delta}$	800@CO_2	0.18@2.0V	2.0@2V	[1]
$La_{0.3}Sr_{0.7}Fe_{0.7}Cr_{0.3}O_{3-\delta}$	300μm@YSZ	$La_{0.3}Sr_{0.7}Fe_{0.7}Cr_{0.3}O_{3-\delta}$	800@CO_2:CO 90:10	0.28@1.5V	1.33@OCV	[2]
$La_{0.3}Sr_{0.7}Fe_{0.7}Ti_{0.3}O_{3-\delta}$	500μm@YSZ	$La_{0.3}Sr_{0.7}Fe_{0.7}Ti_{0.3}O_{3-\delta}$	800@CO2	0.52@2.0V	0.08@2V	[3]
Exsolved Ni $(La_{0.2}Sr_{0.8})_{0.95}Ti_{0.9}Mn_{0.1}Ni_{0.05}O_{3-\delta}$	500μm@YSZ	$La_{0.8}Sr_{0.2}MnO_{3-\delta}$	800@CO_2	0.87@2.0V	0.51@1.6V	[4]
$La_{0.6}Sr_{0.4}Fe_{0.8}Ni_{0.2}O_{3-\delta}$	220μm@YSZ	$(La_{0.6}Sr_{0.4})_{0.95}Co_{0.2}Fe_{0.8}O_{3-\delta}$	800@CO_2:CO 70:30	1.01@2.0V	1.08@OCV	[5]
$La_{0.7}Sr_{0.2}Ce_{0.1}Cr_{0.5}Fe_{0.5}O_{3-\delta}$	300μm@YSZ	$(La_{0.6}Sr_{0.4})_{0.95}Co_{0.2}Fe_{0.8}O_{3-\delta}$	850@CO_2:CO 70:30	0.31@2.0V	0.46@2V	[6]
$La_{0.5}Sr_{0.5}Fe_{0.95}V_{0.05}O_{3-\delta}$	500μm@YSZ	$La_{0.8}Sr_{0.2}MnO_{3-\delta}$	800@CO_2	0.62@1.6V	0.44@1.6V	[7]
Infiltrated $La_{0.9}Ca_{0.1}Fe_{0.9}Nb_{0.1}O_{3-\delta}/Sm_{0.1}Ce_{0.9}O_{2-\delta}$ into porous YSZ	50μm@YSZ	$La_{0.8}Sr_{0.2}MnO_{3-\delta}$	800@ CO_2:CO 50:50	1.0@1.6V	0.42@1.6V	[8]
Exsolved Ni-Fe $Sr_{1.9}Fe_{1.5}Mo_{0.4}Ni_{0.1}O_{6-\delta}$	180μm@YSZ	$La_{0.8}Sr_{0.2}MnO_{3-\delta}$	800@CO_2	2.16@1.5V	0.27@0.3V	[9]
Ni-YSZ	15μm@YSZ	$La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_3$	800@ CO_2:H_2 75:25	1.0@1.3V	0.19 @OCV	[10]
$La_{0.6}Ca_{0.4}Fe_{0.8}Ni_{0.2}O_{3-\delta}$	300μm@YSZ	$La_{0.6}Ca_{0.4}Fe_{0.8}Ni_{0.2}O_{3-\delta}$	800@CO_2	1.41@2.0V	0.05@2V 0.76@OCV	This work

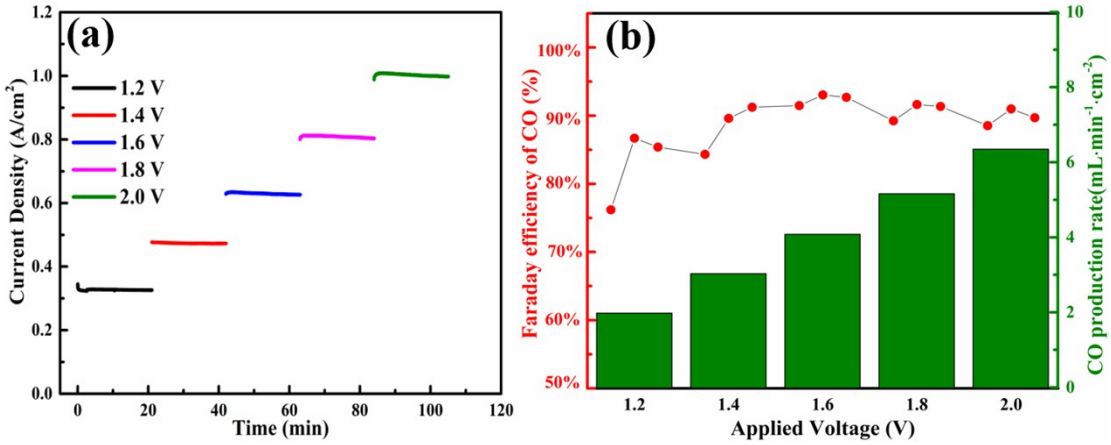

Figure. S6 Short-term performance of CO_2 electrolysis at various voltage with LSrFN symmetrical cell (a); CO production rate and Faraday efficiency of LSrFN symmetrical cell (b) at 800 °C.

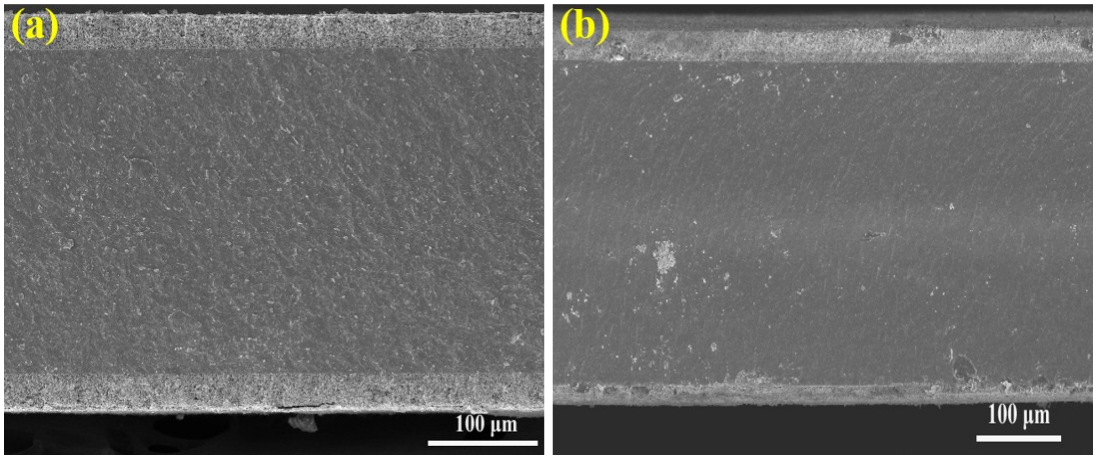

Figure. S7 SEM images of the LCaFN symmetrical cell before (a) and after (b) the electrolysis at 800 °C.

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